Occurrence of the Spirochaete Genus *Cristispira* in Western Canadian Marine Bivalves

BY

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INTRODUCTION

The presence of a large cristaferous unicellular organism in the digestive tract of molluscs has been known since Certes (1882) reported it in *Ostrea edulis* Linnaeus, 1758. Certes (1891) considered it a trypanosome. Laveran & Mesnil (1901) suggested it was a bacterium, while Perrin (1906) placed it among the Protozoa on the basis of the complex cytological organization. Swellengrebel (1907) first recognized the spirochaete affinities and was followed by Gross (1910) who erected the genus *Cristispira* to contain those forms characterized by an encircling crista and the relatively large size. Noguchi (1921) reported upon the distribution of the genus in molluscs collected at Woods Hole, Massachusetts, and Dimitroff (1926) reviewed the literature to that date. Berkeley (1959) first recorded the genus from Western Canada in the large clam *Saxidomus giganteus* (Deshayes, 1841).

METHOD

As many individuals as possible of 63 species of bivalves collected throughout the year from the intertidal to 1700 meters were examined for the presence of *Cristispira*. Examination was made as quickly as possible; in no case more than 10 minutes after collection. One valve was removed and a hypodermic needle inserted dorsally into the stomach and a small amount of stomach contents aspirated. The digestive system was then dissected and duplicate smears taken from the stomach, crystalline style (if present), the style pouch or mid-gut, and the hind-gut. One set of smears was examined at once by means of transmitted and oblique illumination. The second set was fixed in absolute alcohol and stained in Giemsa solution. The distribution of *Cristispira* within the substance of the style of *Saxidomus giganteus* was determined by sectioning frozen styles.

RESULTS

Twelve of the 62 species examined contained *Cristispira*. All of these were suspension feeders, generally belonging to stomach type V (Purchon, 1960). All those with *Cristispira* were intertidal dwellers excepting *Diplodonta orbella* which was collected in 10 m. Some species including *Entodesma saxicola* were found to host *Cristispira* in intertidal situations, but solitary representatives collected by means of SCUBA in 10 - 20 m were invariably free of the spirochaete. A similar situation exists in *Compsomyax subdiaphana*; examination of 79 specimens from various localities in the northern portion of the Strait of Georgia in 60 - 200 m failed to yield *Cristispira*, but in shallower water more southern representatives of the species were hosts (pers. comm., Dr. R. G. B. Reid, University of Victoria). Commercial and natural beds of the Pacific oyster (*Crassostrea gigas*) are frequent hosts; however, no individuals collected from the head of Pendrell Sound contained *Cristispira*.

Considerable variation in infection sites may be demonstrated. In *Saxidomus* the area of maximum infestation is in the style pouch and consequently adhering to the crystalline style. In winter the stomach is often completely free but in summer small isolated numbers of *Cristispira* may be present. In *Tresus* the stomach is the chief site and numbers may be found in the intestine and large numbers in the pallial cavity. Earlier papers suggest that the spirochaete is present within the style substance. Careful sectioning of frozen styles showed that in no case had *Cristispira* penetrated the style but merely formed a

coating on the surface. Adhering *Cristispira* can also be removed by washing the complete style in saline solution and blotting dry.

Numbers of *Cristispira* present vary seasonally, being much more abundant in summer when concentration in the order of 8×10^6 per ml stomach contents may be reached in *Tresus*.

Cristispira are variable in outline and until a culture technique is perfected, it may be prudent to avoid amendments or additions to the nomenclature. Classifications based solely upon external morphology are open to doubt as various histological procedures such as fixation and staining radically alter the appearance. The 7th edition of Bergey (1957) lists 3 species which adequately cover the morphological varieties present in British Columbia marine clams. The results of examination are listed in Table 1 and representatives of each occurrence have been assigned to one of 3 groups; this does not imply any systematic affinity but merely a general group with characters in common.

Type	Similar to	Size	Characteristic
	Cristispira		
δ	*C. balbianii* (Certes, 1882)	40 - 140μ	Obtuse ends
β	*C. anodontae* (Kysselitz, 1906)	44 - 88μ	Pointed ends
α	*C. pinnae* (Gonder, 1908)	10 - 60μ	Blunt ends

DISCUSSION

Berkeley (1959) reported that the crystalline style of *Saxidomus giganteus* contained a large population of *Cristispira* except at the distal end which impinges against the gastric shield where food is broken down and subjected to enzymatic action of the disintegrating style. Previously Berkeley (1933) had demonstrated that one of the products of the oxidizing action of the crystalline style upon plankton was probably glucosone. Berkeley (1962) carried out experiments which showed that plankton extracts were toxic to *Cristispira* suspensions in 60 to 90 minutes and further investigated the toxicity of glucosone. The results showed that addition of 0.5% glucosone to an active suspension of *Cristispira* in sea water held at 5° C rendered inactive all the spirochaetes in approximately one hour. Glucosone has been shown to be toxic to many animals (Becker & Day, 1953). Dean (1958) reported that extracts of style caused rapid dissolution of *Cryptomonas*, though some algae including *Isochrysis* remained unaffected after 72 hours. The lysolytic activity of the style is transitory and present only during active disintegration. Lavin (1946) first reported cellulolytic activity in the styles of *Mactra* and *Mya*. Newell (1953) supported the contention and demonstrated similar activity in *Ostrea edulis* and *Mytilus edulis*, suggesting that cellulosis might be associated with the presence of *Cristispira*. No *Cristispira* has been found in *Bankia setacea*, which would appear to cast doubts upon Newell's suggestion. There is no direct correlation of the occurrence of the spirochaete and species of bivalve, though it appears that closely grouped intertidal populations are the most frequently infected.

The interesting situation where *Cristispira*-free populations of *Crassostrea gigas* and *Venerupis japonica* occupy the head of Pendrell Sound might be explained by the pronounced halocline present in these waters. The summer months are characterized by surface waters of relatively low salinity (10‰ - 20‰) which could have an inhibitory effect upon *Cristispira*. Clams and oysters from the mid region of the Sound demonstrated an infection percentage of 20 - 50, while at the mouth and surrounding areas virtually 100% of susceptible bivalves are infected. A contributing factor might be found in the precipitous walls of the Sound, which offer few suitable habitats for interstitial bivalves which could act as a *Cristispira* reservoir. No difference in conditions between the infected and *Cristispira*-free bivalves could be found, an indication that the spirochaete is not an obligative part of the gut fauna. The presence or absence of *Cristispira* appears to have little effect upon the well-being of the host and should probably be regarded as a commensal organism.

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Table 1

Occurrence of *Cristispira* in Western Canadian Marine Bivalvia

Species	Depth (m)	Number examined	Number positive	Type
Acila castrensis (Hinds, 1843)	146	25	0	
Astarte alaskensis Dall, 1903	180	2	0	
Astarte esquimalti Baird, 1863	23	6	0	
Bankia setacea (Tryon, 1963)	Int.	28	0	
Cardiomya californica (Dall, 1886)	275	14	0	
Cuspidaria pectinata (Carpenter, 1864)	180	3	0	
Cardita ventricosa Gould, 1850	165	6	0	
Chlamys rubida (Hinds, 1845)	110	14	0	
Chlamys hericius (Gould, 1850)	110	9	0	
Clinocardium nuttallii (Conrad, 1837)	Int.	27	25	δ, α
Compsomyax subdiaphana (Carpenter, 1864)	60-200	79	0	
Crassostrea gigas (Thunberg, 1793)	Int.	25	25	δ, α
(Pendrell Sound)	Int.	10	0	
Cuspidaria apodema Dall, 1916	1700	2	0	
Cyclopecten carlottensis Bernard, 1968	1650	1	0	
Diplodonta orbella (Gould, 1851)	10	2	2	
Entodesma saxicola (Baird, 1863)	10	6	0	
Entodesma saxicola (Baird, 1863)	Int.	4	4	δ, β
Gari californica (Conrad, 1849)	18	2	0	
Gari californica (Conrad, 1849)	Int.	14	0	
Glycymeris subobsoleta (Carpenter, 1864)	90	50	0	
Hiatella arctica (Linnaeus, 1767)	40	6	0	
Hinnites multirugosus (Gale, 1928)	20	4	0	
Kellia suborbicularis (Montagu, 1804)	40	2	0	
Lucinoma annulata (Reeve, 1850)	114	18	0	
Lyonsia pugetensis Dall, 1913	Int.	2	2	β, α
Macoma brota Dall, 1916	35	4	0	
Macoma calcarea (Gmelin, 1791)	65	12	0	
Macoma inflatula Dall, 1897	40	6	0	
Macoma nasuta (Conrad, 1837)	Int.	3	0	
Macoma secta (Conrad, 1837)	25	5	0	
Modiolus modiolus (Linnaeus, 1758)	Int.	4	0	
Modiolus capax (Conrad, 1837)	50	5	0	
Mya arenaria Linnaeus, 1758	Int.	3	0	
Mytilimeria nuttallii Conrad, 1837	Int.	2	0	
Mytilus californianus Conrad, 1837	Int.	14	0	
Mytilus edulis Linnaeus, 1758	Int.	35	0	
Nemocardium centifilosum (Carpenter, 1864)	95	8	0	
Nucula carlottensis Dall, 1897	280	4	0	
Nuculana cellulita (Dall, 1896)	750	3	0	
Ostrea lurida Carpenter, 1864	Int.	25	21	δ, β, α
Pandora bilirata Conrad, 1855	365	11	0	
Pandora filosa (Carpenter, 1864)	410	2	0	
Pandora grandis Dall, 1877	250	10	0	
Panope generosa Gould, 1850	Int.	1	1	β, α
Pecten caurinus Gould, 1850	105	5	0	
Pododesmus cepio (Gray, 1849)	Int.	3	0	
Poromya beringiana (Dall, 1916)	750	1	0	
Poromya tenuiconcha Dall, 1913	1385	3	0	
Propeamussium davidsoni (Dall, 1897)	825	6	0	
Protothaca staminea (Conrad, 1837)	Int.	25	24	δ, β, α
Saxidomus giganteus (Deshayes, 1839)	Int.	37	37	δ, β, α
Serripes groenlandicus (Bruguière, 1789)	52	2	0	
Siliqua patula (Dixon, 1789) [1]	Int.	5	0	
Solemya agassizii Dall, 1908	350	8	0	
Solen sicarius Gould, 1850	Int.	1	0	
Tellina carpenteri Dall, 1900	20	4	0	
Tellina salmonea (Carpenter, 1864)	75	15	0	
Thyasira bisecta (Conrad, 1849)	170	2	0	
Thyasira disjuncta (Gabb, 1866)	200	27	0	
Tresus capax (Gould, 1850)	Int.	2	2	β, α
Tresus nuttallii (Conrad, 1837)	Int.	5	5	β, α
Venerupis japonica (Deshayes, 1841)	Int.	25	22	δ, β, α
Yoldia ensifera Dall, 1897	420	22	0	
Yoldia thraciaeformis (Storer, 1838)	100	5	0	
Zirfaea gabbi (Tryon, 1863)	Int.	47	0	

[1] Berkeley (1959) lists *Siliqua patula* as being host to *Cristispira*. This is an error of identification and the record should be referred to *Solen*.

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